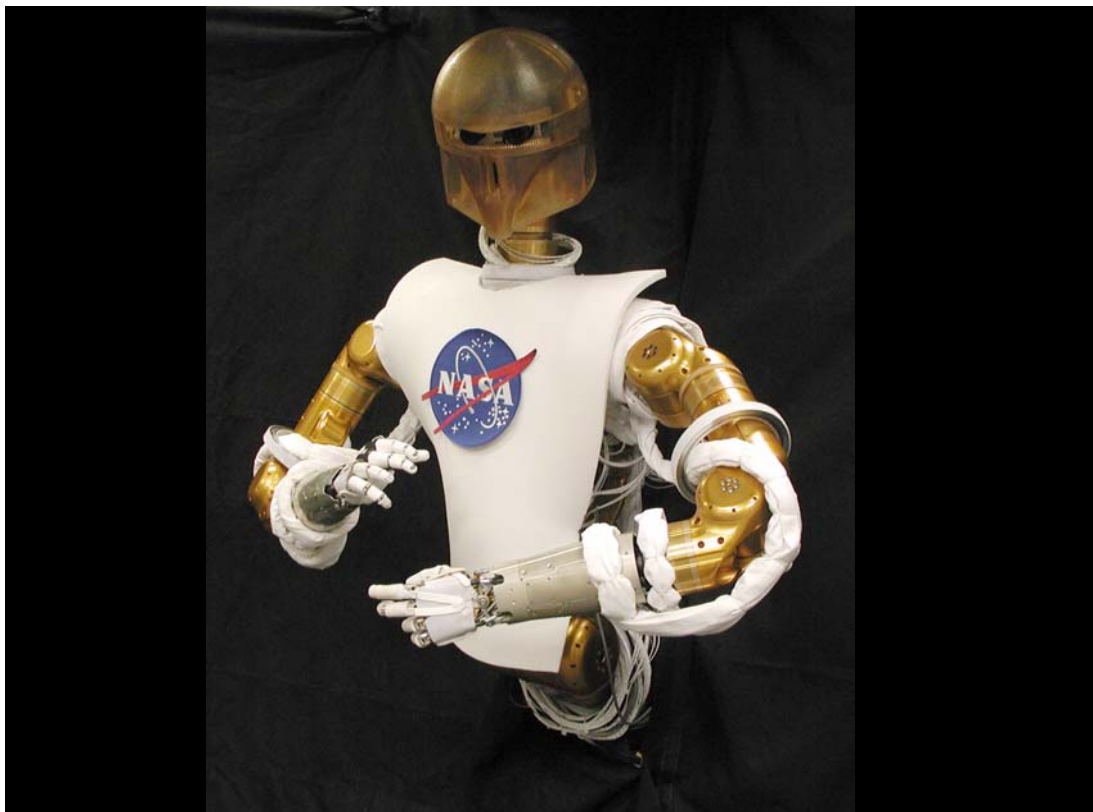




Spacebots

An Educator Guide



Spacebots

A Digital Learning Network Experience



Designed To Share

NASA's Space Exploration Program

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Digital Learning Network (DLN) Expedition

A DLN Expedition is a one time connection that allows students to experience NASA first-hand. Each expedition features an integrated educational package of grade-appropriate instruction and activities centered around a 50 minute videoconference. Students participate in a Question and Answer session with a NASA JSC education specialist or a NASA Subject Matter Expert.

SEQUENCE OF EVENTS

Pre-Conference Requirements

Online Pre-assessment A pre-assessment tool is available to determine the students' level of understanding prior to the videoconference. Suggested answers are included.

Expedition Videoconference

Expedition Videoconference (50 minute conference)

Robots have been a staple of our culture for the past half-century. We have all seen them in movies, on television, and in science fiction stories performing tasks that range from the mundane to the extraordinary. Because of the mental images we have of robots, sparked in great measure by the influence of science fiction, we often fail to recognize how widespread their use is in our daily lives. Everywhere we look, robots and automated systems do work for us and help make our lives more convenient if not easier. Often we do not recognize real robots because they differ from the images we have of them and from the jobs we tend to believe they do. As our society becomes more technologically dependent, however, the role of robots will increase significantly and knowing what they do and how they do it will be an important factor in many professions of the future. NASA already uses robotics technology to great extent in its exploration of space. During this Expedition, students and teachers will have an opportunity to learn firsthand about NASA's use of robots and how they are being designed and built to help humans explore the universe. Learn how NASA defines robotics, see how robotic systems are already widely used in the space program and what plans there are for future robotic applications. This interesting look into the world of space robotics will also highlight educational and professional opportunities that could be the catalyst that helps some students to identify a career path. So join us for this live, interactive learning session for a glimpse into the technologies of the 21st century happening now at NASA.

Post-Conference Requirements

Online Post-assessment

A post-assessment tool is available to determine changes in student levels of understanding.

NASA Education Evaluation Information System (NEEIS) Feedback Forms

Educator and student feedback forms are available online for all DLN events.



Expedition Overview

Grade Level(s) 5-8

Focus Question

How are robotics used in space exploration and what are some of the career opportunities that exist in the field of robotics?

Instructional Objectives (accomplished through videoconferencing and pre- and post-activities)

- Define the term “robot” historically and identify everyday applications.
- Discuss the characteristics of robots and their role-use in space exploration.
- Explore career opportunities and the education required in the field of robotics.

National Standards

Table Below

Texas Standards

Table Below



National Standards

****PLEASE NOTE:** Due to the longevity of standard descriptions, expected student behaviors are listed below as text. The standard is listed in the chart.

National Science Education Standards (NSES) (from www.nap.edu)

<i>Science</i>	End Effector	Tie Shoes	Microrover
Content Standard E: Science and Technology Abilities of technological design	X	X	X
Content Standard G: History and Nature of Science Science as a human endeavor	X	X	X

Student Behaviors:

Content Standard E: Science and Technology

Abilities of Technological Design (5-8): Students in grades 5-8 can begin to differentiate between science and technology, although the distinction is not easy to make early in this level. One basis for understanding the similarities, differences, and relationships between science and technology should be experiences with design and problem solving in which students can further develop some of the abilities introduced in grades K-4. The understanding of technology can be developed by tasks in which students have to design something and also by studying technological products and systems. In the middle-school years, students' work with scientific investigations can be complemented by activities in which the purpose is to meet a human need, solve a human problem, or develop a product rather than to explore ideas about the natural world. The tasks chosen should involve the use of science concepts already familiar to students or should motivate them to learn new concepts needed to use or understand the technology. Students should also, through the experience of trying to meet a need in the best possible way, begin to appreciate that technological design and problem solving involve many other factors besides the scientific issues.

Content Standard G: History and Nature of Science

Science as a human endeavor (5-8): The introduction of historical examples will help students see the scientific enterprise as more philosophical, social, and human. Middle-school students can thereby develop a better understanding of scientific inquiry and the interactions between science and society. In general, teachers of science should not assume that students have an accurate conception of the nature of science in either contemporary or historical contexts. To develop understanding of the history and nature of science, teachers of science can use the actual experiences of student investigations, case studies, and historical vignettes. The intention of this standard is not to develop an overview of the complete history of science. Rather, historical examples are used to help students understand scientific inquiry, the nature of scientific knowledge, and the interactions between science and society.

International Technology Education Association (ITEA) (from www.iteaconnect.org)

ITEA <i>Technology</i>	End Effector	Tie shoes	Microover
Standard 8: Students will develop an understanding of the attributes of design.. (3-5) The design process is a purposeful method of planning practical solutions to problems. (6-8) Design is a creative planning process that leads to useful products and systems.	X	X	X
Standard 9: Students will develop an understanding of engineering design. (3-5) The engineering design process involves defining a problem, generating ideas, selecting a solution, testing the solution(s), making the item, evaluating it, and presenting the results. (6-8) Modeling, testing, evaluating, and modifying are used to transform ideas into practical solutions.	X	X	X

Student Behaviors:

Standard 8: In Grades 6-8, students will learn more about the influence of requirements in the design process. At this age, students can be easily engaged in the identification of problems and opportunities they might pursue.

Standard 9: After an idea has been developed, it is important to test and evaluate the design based on the requirements. This testing and evaluating process leads to the refinement and improvement of the design. Next, the refined design is developed and produced. This may involve making one or more items.

National Council of Teachers of Mathematics (from www.nctm.org)

NCTM <i>Mathematics</i>	End Effector	Tie Shoes	Microover
Standard 21: Connections (K-12) a. Recognize and use connections among mathematical ideas. b. Understand how mathematical ideas interconnect and build on one another to produce a coherent whole. c. Recognize and apply mathematics in contexts outside of mathematics.	X	X	X
Standard 12: Understand measurable attributes of objects and the units, systems, and processes of measurement. (3-5) Understand the need for measuring with standard units and become familiar with standard units in the customary and metric systems (6-8) Understand, select, and use units of appropriate size and type to measure angles, perimeter, area, surface area, and volume.	X	X	X



Texas Standards (TEKS)

Texas Essential Knowledge and Skills (TEKS)

All 5-8 pre-activities meet the following Texas standards:

Science

(3) Scientific processes. The student uses critical thinking and scientific problem solving to make informed decisions. The student is expected to:

(A) analyze, review, and critique scientific explanations, including hypotheses and theories, as to their strengths and weaknesses using scientific evidence and information;

(B) draw inferences based on data related to promotional materials for products and services;

(C) represent the natural world using models and identify their limitations;

(D) evaluate the impact of research on scientific thought, society, and the environment; and

(F) connect Grade 5-8 science concepts with the history of science and contributions of scientists.

(4) Scientific processes. The student knows how to use tools and methods to conduct science inquiry. The student is expected to:

(A) collect, analyze, and record information to explain a phenomenon using tools including beakers, petri dishes, meter sticks, graduated cylinders, weather instruments, hot plates, dissecting equipment, test tubes, safety goggles, spring scales, balances, microscopes, telescopes, thermometers, calculators, field equipment, computers, computer probes, timing devices, magnets, and compasses; and

(B) collect and analyze information to recognize patterns such as rates of change.

Social Studies

(20) Science, technology, and society. The student understands the impact of scientific discoveries and technological innovations on the political, economic, and social development of Texas. The student is expected to:

(A) compare types and uses of technology, past and present;

C) analyze the effects of scientific discoveries and technological innovations, such as barbed wire, the windmill, and oil, gas, and aerospace industries, on the developments of Texas;

(D) evaluate the effects of scientific discoveries and technological innovations on the use of resources such as fossil fuels, water, and land;

(F) make predictions about economic, social, and environmental consequences that may result from future scientific discoveries and technological innovations.

English

(20) Writing/inquiry/research. The student uses writing as a tool for learning and research. The student is expected to:

(A) frame questions to direct research (4-8);

(B) organize prior knowledge about a topic in a variety of ways such as by producing a graphic organizer (4-8);

(C) take notes from relevant and authoritative sources such as guest speakers, periodicals, and on-line searches (4-8);

(D) summarize and organize ideas gained from multiple sources in useful ways such as outlines, conceptual maps, learning logs, and timelines (4-8);

(E) present information in various forms using available technology (4-8);

(F) evaluate his/her own research and frame new questions for further investigation (4-8); and

(G) follow accepted formats for writing research, including documenting sources (6-8).



A week before the event, students will need to take the online pre-conference assessment. This short assessment will provide useful background information for the presenters to prepare for the videoconference.

- Page 11

- 3) Write a set of directions on how to move your arm from your side to scratch your nose. This will be a set of program directions similar to those written by engineers working to design a robotic system for movement to complete a task.

4) Match the following terms with their correct definitions:

Articulated		A mechanical or electromechanical device that performs human tasks, automatically or by remote control.
End Effector		The study and application of robot technology.
Degrees of Freedom		Each plane in which a robot can maneuver.
Anthropomorphic		To move by turning over and over. To rock back and forth.
Dexterity		Jointed arm.
Yaw		To move left or right with out turning over or moving up or down
Pitch		To control a device or object from a distant location.
Roll		To have human characteristics.
Autonomous		A robot that is operated remotely.
Robot		Device at the end of a robot arm that is used to grasp or engage objects.
Telerobotics		To rise up or dip down.
Teleoperation		Skill, flexibility, and range of mobility.
Robotics		Existing or functioning independently



Pre-Conference Requirements

Teacher's Page with suggested answers:

Answers to Pre and Post Assessment Questions

1. **Answers vary**
2. **Students draw picture**
3. **Answers vary**
4. **Articulated** – Jointed arm.

End Effector – Device at the end of a robot arm that is used to grasp or engage objects.

Degrees of Freedom – Each plane in which a robot can maneuver.

Robot – Mechanical or electromechanical device that performs human tasks, either automatically or by remote control (From the Czech word robota).

Robotics – Study and application of robot technology.

Telerobotics – Robot that is operated remotely.

Teleoperation – To control a device or object from a distant location.

Anthropomorphic – To have human characteristics.

Dexterity – Skill in using one's hands, body, or mind. Skill, flexibility, and range of mobility.

Pitch – To rise up or dip down.

Roll – To move by turning over and over. To rock back and forth.

Autonomous – existing or functioning independently.

Yaw – To move left or right without turning over or moving up or down.



Expedition Videoconference Guidelines

Audience Guidelines

Teachers, please review the following points with your students prior to the event:

- Videoconference is a two-way event. Students and NASA presenters can see and hear one another.
- Students are sometimes initially shy about responding to questions during a distance learning session. Explain to the students that this is an interactive medium and we encourage questions.
- Students should speak in a loud, clear voice. If a microphone is placed in a central location instruct the students to walk up and speak into the microphone.
- Teacher(s) should moderate students' questions and answers.

Teacher Event Checklist

Date Completed	Pre-Conference Requirements
	1. Print a copy of the module.
	2. Have the students complete the online pre-assessment.
	3. Email questions for the presenter. This will help focus the presentation on the groups' specific needs.
	4. Review the Audience Guidelines, which can be found in the previous section.
	Day of the Conference Requirements
	1. The students are encouraged to ask the NASA presenter qualifying questions about the Expedition.
	2. Follow up questions can be continued after the conference through e-mail.
	Post - Conference Requirements
	1. Have the students take the online Post-Assessment to demonstrate their knowledge of the subject.
	2. Use the provided rubric as guidelines for content and presentation criteria.
	3. Teacher(s) and students fill out the event feedback.



Expedition Videoconference Outline

Introduction to Challenge Videoconference

Robots have been a staple of our culture for the past half-century. We have all seen them in movies, on television, and in science fiction stories performing tasks that range from the mundane to the extraordinary. Because of the mental images we have of robots, sparked in great measure by the influence of science fiction, we often fail to recognize how widespread their use is in our daily lives. Everywhere we look, robots and automated systems do work for us and help make our lives more convenient if not easier. Often we do not recognize real robots because they differ from the images we have of them and from the jobs we tend to believe they do. As our society becomes more technologically dependent, however, the role of robots will increase significantly and knowing what they do and how they do it will be an important factor in many professions of the future. NASA already uses robotics technology to great extent in its exploration of space. During this Expedition, students and teachers will have an opportunity to learn firsthand about NASA's use of robots and how they are being designed and built to help humans explore the universe. Learn how NASA defines robotics, see how robotic systems are already widely used in the space program and what plans there are for future robotic applications. This interesting look into the world of space robotics will also highlight educational and professional opportunities that could be the catalyst that helps some students to identify a career path. So join us for this live, interactive learning session for a glimpse into the technologies of the 21st century happening now at NASA.

Outline for Video Conference

- I. Welcome**
- II. Introduction**
- III. History of Robots**
- IV. Today's Robots**
- V. Robotics Terms**
- VI. NASA Robots**
- VII. Careers**
- VIII. Q&A**
- IX. Good-Bye**



5-8 Activity #1

Article: Astronauts' Little Helper

In the near future, a day in the life of an astronaut may include being awakened in the morning by a personal assistant that also provides a briefing for the coming day. There may be computer files to check, experiments to monitor, inventories to update, web sites to consult, reports to file...and for each task, the astronaut's assistant keeps track of progress, notes unusual circumstances, and provides feedback.

The assistant also keeps a log of conditions on the Space Shuttle or Space Station: if levels of oxygen, hydrogen, or **emissions** reach critical levels, the assistant lets everyone know. When a **videoconference** is needed, the assistant is right there to provide the hookup and transmission needs.

That's a mighty busy assistant! The surprising part is that this assistant isn't a human; it's a robot. To most people, however, this robot doesn't look like anything they might expect. Not at all **humanoid**, this robot looks like...a grapefruit. A large, red, flying grapefruit, to be sure, but still, a grapefruit. It's packed full of sensors, miniaturized video equipment, wireless network equipment, and technology. This allows the robot to understand spoken commands and reply with the same.

"We're developing an intelligent robot that essentially can serve as extra eyes, ears, and nose for the crew and ground-support personnel," says Yuri Gawdiak. He is the principal researcher for the Personal Satellite Assistant (PSA) in development at NASA's Ames Research Center in California. "The PSA will allow scientists to interact naturally with the crew. Because it's not a humanoid shape, it will offer more **dexterity** and enhanced performance because it can travel where people can't." **Prototypes** are being developed; a test flight is planned for mid-2002, and a year later, the PSA could be on the job up in space.

Developing the PSA has presented scientists with enormous challenges. PSA will operate in microgravity conditions, and it's difficult to simulate those settings here on Earth. "There will be lower power requirements up in space for the robot to move," says Gawdiak. "On the Space Station, it takes far less effort and much reduced power requirements."

The PSA is eerily close to the flying bot that taught Luke Skywalker to fight with a light saber in *Star Wars*. It floats in microgravity, and propels itself by using small fans, moving not just up and down and back and forth, but in a full range of motions, darting and zooming like a hummingbird. PSA maneuvers tight corners, records actions on video, and can go where humans can't—to check on a potentially hazardous situation, for instance. Besides alerting astronauts to dangerous situations, the PSA can also take care of **tedious** tasks ranging from inventory control to monitoring experiments to taking the night sentry shift.



Because it's computer based, the PSA can transfer data between the spacecraft's main computers and those on the ground at mission control. PSA can receive programmed instructions and be modified as needed. PSA can serve as a video outlet for communicating between Earth and space. Because it's so personally programmable, PSA will be able to learn how each user wants to be assisted, Gawdiak says. "PSA will learn whether you want it to fly beside you or behind you. It will learn your schedule, get you the updates you want from the ground, and interact with you on a highly personal scale. It won't just be mobile; it will understand much of what you want it to do."

"Operations we take for granted are very hard to program into a robot," Gawdiak says. "Something as basic as deciding where and when to go to a location, and how to react to variables that might come up along the way are enormously complex programs. The technology that has come about to create the PSA is directly transferable to Earth. In any system—a subway or a factory, for instance—robots can be assigned the mundane and dangerous situations, rather than humans. Managing inventory, monitoring hazards, and performing security can be done by robots to spare humans the risk."

Robotic Arm

Teacher Sheet(s)

Objective: To learn how the end effectors for the robotic arms used on the Space Shuttle and the International Space Station work. Students will design and construct a grapple fixture that will enable the end effector to pick up an object.

Level: 5-8

Subjects(s): Science, Technology

Prep Time: Less than 10 minutes

Duration: One Class Period

Materials Category: Common Household

Materials:

- Styrofoam coffee cups
- String—12-cm pieces
- Cellophane tape
- Plastic picnic knives (serrated)

Related Links:

NASA Site used for derivation of Lesson Plan

[Spacelink - Humans And Robots](#)

Supporting Article(s):

Astronauts' Little Helpers

Pre-Lesson Instructions:

In this activity, students can work singly or in small groups of two or three. Have students use a sawing motion to cut through the cups. It is easier to cut through the outer cup first and then the inner cup. The important part about cutting the two cups is that their cut-off ends lie flush with each other when the cups are nested. Use the knives as scrapers to smooth the cut edges.

Upon completing the end effector, have your students design a grapple fixture. The idea here is to design something that the end effector can grab onto without slipping off. After grapple fixtures are completed, tell students to compare their fixtures to those created by two other students or groups. Ask them to create a table or a chart comparing the strong and weak points of the fixtures they evaluated. They should summarize their results with a statement about how they can improve the fixture they designed.

Background Information:

The International Space Station (ISS), currently under construction in Earth orbit, will have several robots to help astronauts complete their tasks in space. Five of the ISS international partner nations are developing robotic systems for the station. Japan is developing the Japanese Experiment Module (JEM) Remote Manipulator System. The European Space Agency and the Russian Space Agency are developing the European Robotic Arm. Canada and the United States are developing the Mobile Servicing System (MSS). The MSS, pictured on the Student Sheet, has an effector on each end allowing it to inch-worm along the structure of the ISS.

Guidelines:

1. Read the 5-8 article, "Astronauts' Little Helpers."
2. Discuss the other robots that are going to be used on the International Space Station.
3. Go over the procedure on the Student Sheets.

Discussion/Wrap-up:

- Review the tables or charts created by your students. Pay special attention to the ideas students have for improving their grapple fixtures.
- Discuss the strengths and weakness of the improved grapple features. Remember that these fixtures will have to be attached to anything the robotic arm wants to grab.

Extensions:

- Search robot sites on the Internet, and review different end effector designs. How does the design of an end effector enable it to pick up and manipulate various objects?

Robotic Arm

Student Sheet(s)

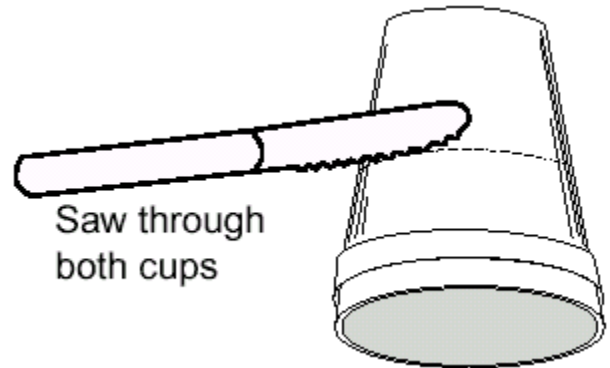
Materials

1. Styrofoam coffee cups (two)
2. String-12-cm pieces (three)
3. Cellophane tape
4. Plastic picnic knives (serrated)

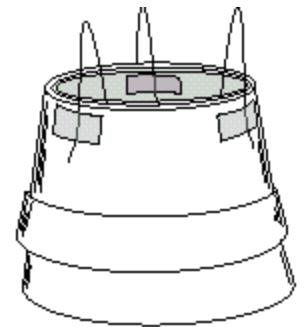
Procedure

Making the End Effector:

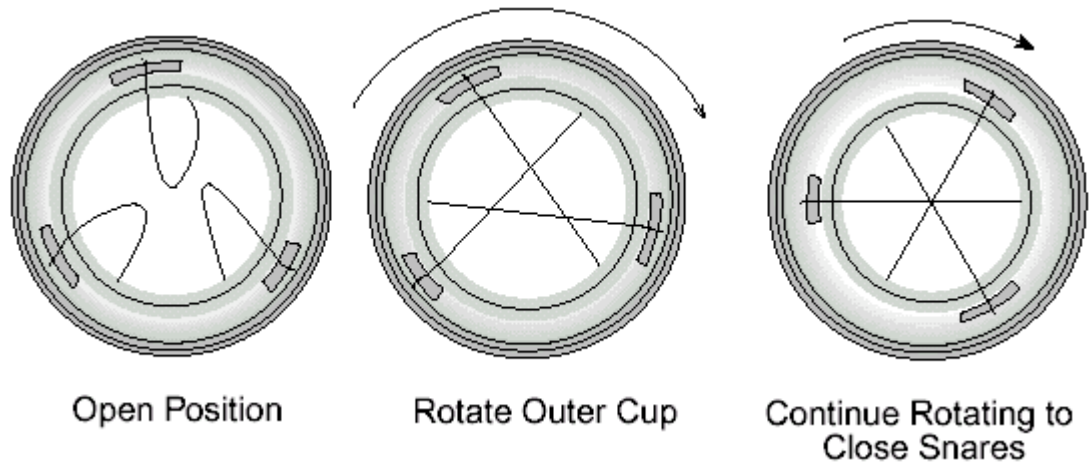
1. Nest the two cups together, and cut through both cups where indicated by the dashed line in the diagram. Smooth the cut edges by scraping them with the picnic knife edge.
2. Cut three pieces of string 12 centimeters long each.
3. Tape the end of the first string to the inside of the inner coffee cup just below the cut edge. Tape the other end of the string to the outside of the cup, but do not press this piece of tape tightly yet.
4. Repeat step 3 twice more, but place the strings about 1/3 of the way (120 degrees) around the cup from the first string.
5. While holding the rim of the inner cup, rotate the outer cup until the three strings cross each other. The strings will have some slack. Pull the end of the strings on the outside until they are straight and intersect exactly in the middle of the opening. Press the tape on the outside to hold the strings.



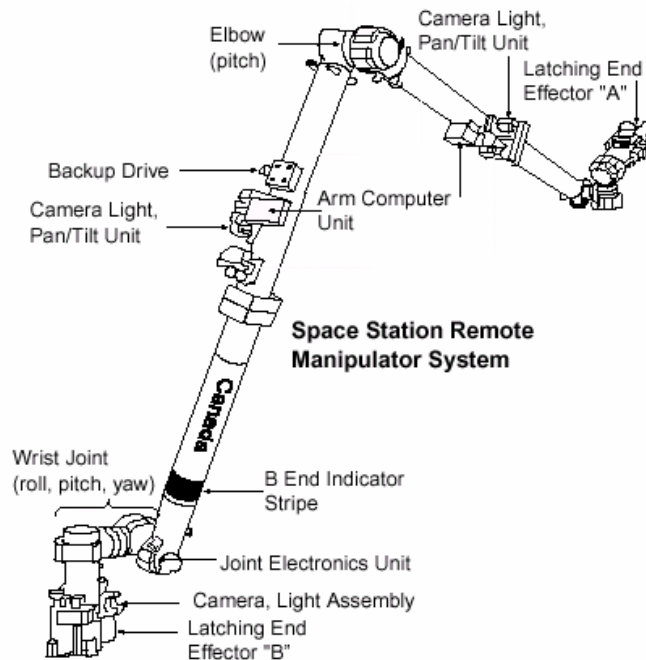
Tape string loop from outside to the inside



Using the End Effector



1. Use the end effector to pick up an object such as a pencil. Have someone hold a pencil upright. Open your end effector so that the strings are not crossing each other. Slip the end effector over the pencil so that the pencil extends down the center and not through any of the loops. Rotate the outer cup until the strings grasp the pencil. Pick up the pencil.
2. You may find that the pencil is too slippery to be held securely. How might you modify the pencil so that it can be held? Design a standard grapple fixture that can be mounted to other objects so that they can be picked up.
3. Compare your grapple fixture to two other grapple fixtures designed by your classmates. Which one works the best? Why? Create a chart or a table that evaluates the strong and weak points of each grapple fixture you compared. How can you improve your design?





5-8 Activity #2

Can a Robot Tie Your Shoes?

Robots are machines that do specific tasks. Movies are full of robots that can do everything that humans can do and more. However, in reality, there are limits to what robots can do. This activity is designed to help analyze a simple, everyday task from the point of view of a robot. Gloves, blindfolds and pliers are used to limit sensory information, and tongue depressors limit the number of moving joints.

Tying a shoe, an every-day task that seems easy enough for us, is difficult, if not impossible, for a mechanical robot. Robots have limited movement, only a few sensors, and are controlled by computers, which must be programmed with instructions for each step required. It is difficult for two people to work together to tie a shoe. Likewise two robots working together is very difficult to coordinate and only recently has been achieved. (A line of robots working sequentially in an assembly plant is different than two robots working together on the same task.)

It is helpful for participants to discuss their experience after each variation.

Materials Needed

- shoes that tie
- tongue depressor
- masking tape
- heavy gloves
- 2 pairs of pliers
- blind folds



Try tying your shoes blindfolded. Not too hard! Now, repeat the activity but with heavy gloves on your hands. Then, tape tongue depressors onto your thumbs and forefingers and try again.

And if those activities weren't difficult enough, tie your shoes with pliers. First, use pliers in both hands; then with only one hand; finally with two people -- each with one pair of pliers. For fun, these activities can be set up as a race between two people



5-8 Activity #3

Design a Microrover for the Moon

Materials

- paper
- art supplies
- assorted materials (plastic food containers, Styrofoam packaging, spools, broken toys, etc.)
- glue
- tape

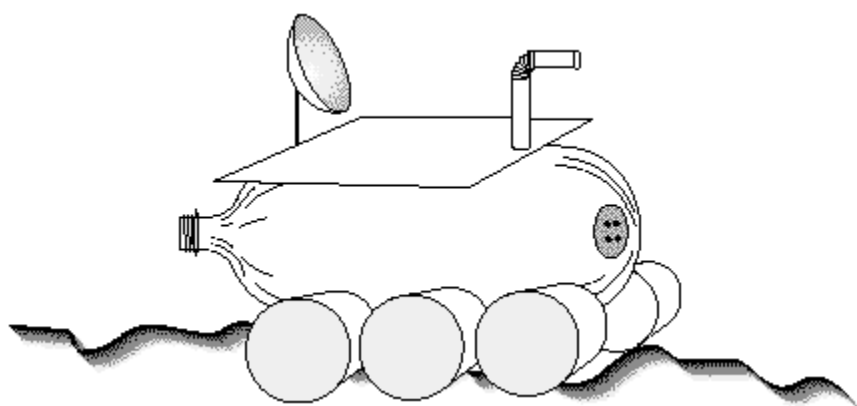
Background

NASA has shifted its planetary exploration strategies from complex and expensive "do-everything" spacecraft to simpler and less expensive spacecraft that do only a few jobs. A good example of this operational change is the Sojourner microrover robot spacecraft that explored small areas of the Martian surface in 1997.

Microrovers are easier to design and construct than the larger complex craft and several can be constructed for the same price. If a major malfunction should take place in one rover, others can be deployed to replace it. Recent studies of the Moon by the robot Lunar Prospector spacecraft have confirmed that water, in the form of ice, exists at the Moon's South Pole. The water is found in depressions that are forever shielded from the Sun's heat. The discovery of water means that future human explorers of the Moon can use the water for drinking, for production of breathing oxygen, and for production of rocket fuel.

Procedure

Challenge students to design a microrover spacecraft for exploring the Moon's South Pole region. The purpose of the rover is to map the extent of water ice found there. The robot will have to have some sort of transportation system, sensors, power, scientific instruments, and a communication system. Have students sketch their robot design or construct a model of the robot from assorted materials. Have students write a description of how their robot works or present an oral report.





After the event students will need to take the online post-conference assessment. (These questions are the same questions used in the pre-assessment.) The short assessment will help us measure student learning and identify any changes that need to be made in future programs.

Post-Conference Assessment Questions

- 1) Provide a written definition of a Robot. What can a robot do? What does a Robot look like?

3) Write a set of directions on how to move your arm from your side to scratch your nose. This will be a set of program directions similar to those written by engineers working to design a robotic system for movement to complete a task.

4) Match the following terms with their correct definitions:

Articulated		A mechanical or electromechanical device that performs human tasks, automatically or by remote control.
End Effector		The study and application of robot technology.
Degrees of Freedom		Each plane in which a robot can maneuver.
Anthropomorphic		To move by turning over and over. To rock back and forth.
Dexterity		Jointed arm.
Yaw		To move left or right with out turning over or moving up or down
Pitch		To control a device or object from a distant location.
Roll		To have human characteristics.
Autonomous		A robot that is operated remotely.
Robot		Device at the end of a robot arm that is used to grasp or engage objects.
Telerobotics		To rise up or dip down.
Teleoperation		Skill, flexibility, and range of mobility.
Robotics		Existing or functioning independently



NASA Education Evaluation Information System (NEEIS)

Please complete an online evaluation form to provide feedback on the NASA Expedition.

Feedback from you and a few of your students would be appreciated.

<http://dln.nasa.gov/dln/content/feedback/>

National Aeronautics and Space Administration



NASA Digital Learning Network

presents

Certificate of Completion

to

for

Spacebots

Instructor

Date



Vocabulary

Articulated – Jointed arm.

End Effector – Device at the end of a robot arm that is used to grasp or engage objects

Degrees of Freedom – Each plane in which a robot can maneuver.

Robot – Mechanical or electromechanical device that performs human tasks, either automatically or by remote control (From the Czech word robota).

Robotics – Study and application of robot technology.

Telerobotics – Robot that is operated remotely.

Teleoperation – To control a device or object from a distant location.

Anthropomorphic – To have human characteristics.

Dexterity – Skill in using one's hands, body, or mind. Skill, flexibility, and range of mobility.

Pitch – To rise up or dip down.

Roll – To move by turning over and over. To rock back and forth.

Autonomous – existing or functioning independently.

Yaw – To move left or right without turning over or moving up or down.



Resources

Robotics Education Project - The NASA Robotics Education Project (RE) is dedicated to encouraging people to become involved in science and engineering, particularly building robots. Visit this website to learn about robotics competitions and how to get involved.

<http://robotics.nasa.gov/>

NASA Space Telerobotics Program - This program is an element of NASA's ongoing research program, under the responsibility of the Office of Space Science. The program is designed to develop telerobotic capabilities for remote mobility and manipulation, by merging robotics and teleoperations and creating new telerobotics technologies. http://ranier.hq.nasa.gov/telerobotics_page/telerobotics.shtm

A great NASA site for **robotic rover technology research** being conducted at the Jet Propulsion Lab in California.

<http://www-robotics.jpl.nasa.gov/videos/index.cfm>



Background Information

Robotics Competitions

<http://robotics.nasa.gov/students/challenge.php>

Ask a Robotocist.

<http://robotics.nasa.gov/students/robotics.php>

Phoenix Mars Mission: Just for Kids

<http://phoenix.lpl.arizona.edu/kids.php>

Mosaic Robot Puzzle

http://spaceplace.nasa.gov/en/kids/robots/robot_puzzle.shtml



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